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Estimation of Fall Chum Salmon Abundance On the Tanana and Kantishna Rivers Using Mark Recapture Techniques, 2000

by

Peter M. Cleary

Toshihide Hamazaki

State of Alaska

Tony Knowles, Governor

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AUTHOR

Peter M. Cleary is a Fishery Biologist for the Alaska Department of Fish and Game, Division of Commercial Fisheries, 1300 College Road, Fairbanks, AK 99701.

Toshihide Hamazaki is the Regional Biometrician for the Alaska Department of Fish and Game, Division of Commercial Fisheries, 333 Raspberry Road, Anchorage, AK 99518.

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ABSTRACT

Mark recapture studies on fall chum salmon (*Oncorhynchus keta)* were conducted for the sixth consecutive year on the Tanana River and for the second year on the Kantishna River.

In the Tanana River, chum salmon were captured and tagged using a fish wheel located on the right bank of the river, immediately upstream of the Kantishna River mouth, and recaptured in a fish wheel located approximately 76 km upriver on the right bank. In the Kantishna River, chum salmon were captured in a fish wheel on the left bank of the river, approximately 9-km upstream of its terminus on the Tanana River, and recaptured in three fish wheels; two fish wheels were located approximately 113 km upstream in the Toklat River, and the other fish wheel was located 139 km upstream on the Kantishna river.

These studies were conducted in August and September 2000 on both the Tanana and Kantishna Rivers. The final Bailey model abundance estimate for the upper Tanana River was 34,844 (SE = 4,970). The final Bailey population estimate for the Kantishna River was 21,450 (SE = 3,031).

KEY WORDS: Yukon River, mark-recapture, population size, escapement, migration rate, run timing

INTRODUCTION

The Yukon River drainage is the largest in Alaska (854,700 km^2), comprising nearly one-third the area of the entire state. Five species of anadromous Pacific salmon return to the Yukon River and its tributaries and are utilized in subsistence, personal use, commercial, and sport fisheries. The Tanana River is the largest tributary of the Yukon River. It flows northwest through a broad alluvial valley for approximately 700 km to the Yukon River, draining an area of 115,250 km^2. Chum salmon (*O. keta)* return to the Yukon River in genetically distinct summer and fall runs (Seeb et al. 1995). Summer chum salmon begin to enter the Yukon River in early May, and fall chum salmon enter in mid July. Fall chum salmon migration typically peaks around mid-September in the Tanana River and continues into early October. Spawning occurs from October through November, primarily in areas where upwelling ground water prevents freezing. Fall chum salmon are larger on average than summer chum salmon, have a higher oil content, and are an important subsistence and personnel use fish harvested in the Upper Yukon and Tanana Rivers.

The Tanana River drainage is a major producer of Yukon River fall chum salmon and contributes to the various in river fisheries. The most recent 5-year (1995-1999) average total harvest of fall chum salmon in the Tanana River is approximately 45,697 fish; approximately 24% of the entire Yukon River drainage's average catch for those years (Bergstrom et al. 2001). The Alaska Department of Fish and Game (ADF&G) has management responsibility for fisheries in the Alaska portion of the Yukon River drainage. For management purposes, the drainage is divided into 13 districts and subdistricts. The Tanana River (District 6) is divided into three subdistricts, 6-A, 6-B, and 6-C and the area known as the upper Tanana River (Figure 1). Tanana River summer and fall chum salmon are managed as distinct stocks and are divided into summer and fall seasons according to the established date of 16 August. Although some overlap in their migrations does occur, this date has been selected for management purposes based on average historical run timing. Subsistence and personal use fisheries are typically open for two 42-hour periods per week, with the exception of the Old Minto area where subsistence fishing is allowed five days a week. Commercial fishery openings occur on the Tanana River in Subdistricts 6-B and 6-C by emergency order for a maximum of one 42-hour period per week (limited to one 24 hour period per week in Subdistrict 6-A). The Tanana River commercial guideline harvest range is 2,750 to 20,500 fall chum salmon, but the harvest level may be exceeded if escapement goals and subsistence needs are satisfied. In 2000, however, no commercial fishery was permitted because the fall chum salmon run was much weaker than had been anticipated. In addition, subsistence fishing on the Tanana River was closed most of the season with the exception of two 12-hour periods, one 6-hour period, and one 24-hour period when subsistence fishing was open for coho salmon (*O kisutch)*. Gear restrictions required using live chutes to release any chum salmon captured.

Aside from information provided by this project, management decisions for the Tanana River are partially based on catch-per-unit-effort (CPUE) data from department-contracted "test" fish wheels and fishery performance data. Data obtained from these sources are used inseason to qualitatively assess run strength. However, these data have serious limitations, and managers are unable to use them to assess absolute run strength. Fish wheels are susceptible to inconsistencies

in efficiency, both within and among years. Although attempts are made to fish test wheels at the same location each year, conditions at a given location may change annually in relation to water level, current and channel location. The Tanana River is very dynamic, and these factors are known to fluctuate widely. This variability reduces the reliability of test fish wheel data for making inseason management decisions.

Fishery managers also rely on aerial and ground surveys of selected fall chum salmon spawning areas. For example, ADF&G has established minimum escapement goals for fall chum salmon of 15,000 to 33,000 in the Toklat River, a tributary of the Kantishna River, 6,000 to 13,000 in the Delta River and 61,000 to 136,000 in the Tanana River (Eggers 2001). Intensive annual ground surveys are conducted on spawning grounds in each of these rivers to estimate salmon escapement. In addition, a sonar project using Bendix sonar gear was operated in the Toklat River from 1994 to 1996 to develop a better assessment of escapement because it is an important fall chum salmon tributary (Barton L. H. 1997). A main river sonar project located at river mile 123 near the village of Pilot Station estimates passage of all salmon species in the lower Yukon River. Projects also exist that estimate spawning escapement of fall chum salmon in the Yukon River tributaries, including the Chandalar, Delta, Toklat, Sheenjek and Fishing Branch Rivers (JTC 2001). Prior to 1995, however, there has never been an operational, on-going program to estimate fall chum salmon population size in the Tanana River. While estimates provided by the main river sonar project may be valuable for the drainage as a whole, operational aspects and the cost of combining acoustic estimates of abundance with stock identification techniques complicate determination of the strength of the Tanana River fall chum salmon component. The U.S. Fish and Wildlife Service (USFWS) implemented a mark-recapture project located at Rampart Rapids on the Yukon River, 58 km upriver of the Tanana-Yukon River confluence, in 1996 to estimate population size of fall chum salmon in the Yukon River drainage upstream of the village of Rampart (Gordon et al. 1998). Results from this project have the potential to verify Tanana River population estimates. Although inseason assessment of drainage-wide Yukon River fall chum salmon run strength is extremely important, it may not accurately reflect the strength of the Tanana River run component in a given year because of differences between run strength and run timing between Tanana and non-Tanana stocks. Consequently, a reliable inseason estimate of run strength would prove very useful for management. Previous efforts, limited to one or two years, (Buklis 1982; Barton 1992; LaFlamme 1990) have been made to estimate population size and identify fall chum salmon spawning areas using mark recapture

The Tanana River fall chum salmon mark-recapture project was initiated in 1995. Two tag deployment fish wheels and two tag recovery fish wheels were used to sample each riverbank with equal effort. However, the fall chum salmon catch from the left bank recovery wheel was approximately 3% of the catch from the right bank recovery wheel. After testing for bank orientation, technicians determined that the left bank tag deployment wheel was unnecessary, and it has not been used since (Cappiello and Bromaghin 1997). In 1996, the Bailey model was used for making inseason population estimates. However, postseason data did not satisfy model assumptions, as the probability of recapture was not constant through time (Cappiello and Bruden 1997; Hebert and Bruden 1998). In 1998, the marked proportion in the recovery fish wheels was not consistent (Cleary and Bruden 2000). Consequently, the Darroch model was used once more for the Tanana River estimate. In 2000, one tagging fish wheel and one recovery wheel were used in the Tanana River. One tagging wheel was operated in the Kantishna River,

two recovery fish wheels were used in the Toklat River, and one recovery wheel operated in the upper Kantishna River. The Bailey population model was used to generate Tanana and Kantishna River population estimates in 2000 (Table 1).

Objectives for the 2000 season were to: (1) provide inseason and postseason abundance estimates of fall chum salmon in the upper Tanana and Kantishna Rivers; (2) estimate migration rates for fall chum salmon; (3) estimate run timing of selected stocks in the Tanana River drainage (e.g., Delta River) and the Toklat River (Kantishna River drainage); and (4) estimate run timing, strength and the marked proportion of upper Kantishna River fall chum salmon.

METHODS

Sampling

The Tanana and Kantishna River mark-recapture studies utilized tag deployment and recovery fish wheels. In the Tanana River, one tagging wheel was located 9 km above the Kantishna River mouth, and one recovery fish wheel was located 76 km upstream of the tagging site and below the Nenana River (Figure 2). These two locations were selected because of the absence of main tributaries between the two sites (with the exception of the Tolovana River), which satisfies a 'closed population' (i.e., no immigration, emigration, mortality) assumption, the main premise of the mark-recapture study.

Because the Kantishna River branches into the upper Kantishna and Toklat River 58 km upstream of the tagging site, recovery sites were located in both the Toklat and upper Kantishna Rivers. The Toklat River recovery site is located 114 km upstream of the Kantishna River tagging fish wheel where two tag recovery fish wheels were operated on the left and right banks of the river. The Upper Kantishna recovery fish wheel was operated 139 km upstream of the Kantishna River tagging wheel on the right bank of the river. By operating two recovery fish wheels, the 'closed population' assumption was satisfied.

Tag Deployment

The Tanana and Kantishna River tagging fish wheels are owned and operated by private contractors. In the Tanana River, the fish wheel was positioned on the right bank at approximately 8 km upstream from the mouth of the Kantishna River and within 100 meters of the 1995-1999 fish wheel locations (Figure 2). This site has a stable river channel and slow current that provides a relatively consistent location for fish wheel operation. In the Kantishna River, a tagging fish wheel funded by the Bering Sea Fisherman's Association (BSFA) was positioned on the left bank at approximately 9 km above the mouth of the river. Both tagging fish wheels were equipped with two baskets measuring 2.5-3 m in width with a dip capacity of

approximately 4 m and a live box measuring 2.4 x 1.2 x .06 m (length, width, depth) constructed of spruce poles and one-half inch plywood submerged on the offshore side of the fish wheel. A maximum of three fish leads, ranging from 2 to 5 meters in length, were installed shoreward as needed, depending on the distance of the fish wheel from the river bank. The contractors examined their respective wheels at least once a day to determine overall operating efficiency, to check for damage such as tears, rips or holes in the baskets or live-box, and to remove any accumulated debris. To maximize operating efficiency, the fish wheels were occasionally adjusted by moving the wheel laterally, raising or lowering the axle to allow baskets to turn as close to the bottom as possible, lengthening or shortening onshore fish leads, and adding or removing basket paddle boards to accommodate changes in river current.

Unless interrupted by debris accumulation or wheel relocation, the two tag deployment fish wheels were operated 24 hours per day. The tagging fish wheels operated from 18 August until 29 September on the Tanana River and from 16 August to 25 September on the Kantishna River. At each location, a daily 12-hour tag deployment schedule was maintained from 08:00 to 20:00, with a 24-hour catch-day designated as 08:00 to 08:00 the following day. The sampling crew checked the live-box at each wheel in approximately 4-hour intervals (07:30, 12:00, 16:00 and 19:30). Using a dip net, all chum salmon in the live-box were individually transferred to a sampling table. The fish were tagged with a 30 cm, hollow core, individually numbered spaghetti tag (Floy Tag and Manufacturing Inc., Seattle, WA)[2] that was inserted with a 16 cm applicator needle into the dorsal musculature, posterior to the dorsal fin, and secured with an overhand knot tied close to the body. Orange tags were used on the Tanana River and pink tags on the Kantishna River. The right pelvic fin was also partially clipped as a secondary mark. Other data recorded were: (1) length, measured from mid-eye to fork-of-tail (MEFT) at nearest five cm; (2) sex, determined by external physical appearance; (3) condition, determined by external physical aberrations subjectively judged as having the potential to affect survival or migration; and (4) exterior color, graded by light or dark. Fish caught between 08:00 and 20:00 were categorized as day fish, while fish caught between 20:00 and 08:00 and held in the live-box for up to 12 hours were categorized as night fish. Total handling time per fish was approximately one minute. All chinook salmon (*O. tshawytsha)* and coho salmon were enumerated by sex and released, while other species were identified, enumerated, and released.

Wheel revolutions occurring over 15-minute intervals were recorded daily. In addition, meteorological data, water temperature and level, were recorded once a day at the tagging camp at approximately 10:00. Data collected after each sampling session were entered into a computer spreadsheet. A data summary for the previous 24-hour tagging day was reported daily to the ADF&G Fairbanks office via cellular or satellite telephone.

Tag Recovery

The recovery fish wheels in the upper Tanana River and upper Kantishna River were owned and operated by private contractors, while the Toklat River recovery wheel was operated by

[2] Mention of trade names does not constitute endorsement by ADF&G.

ADF&G. In the upper Tanana River, one wheel was positioned on the right bank approximately 76 km from the tagging fish wheel (Figure 2). Design, size and construction materials of the recovery fish wheels and live-boxes were similar to those of the tag deployment fish wheels. The Tanana River recovery wheel also served as an ADF&G management test fish wheel and was operated during both the summer and fall chum salmon migrations.

Recovery fish wheels operated through 2 October on the Tanana River, through 28 September on the Toklat River, and through 2 October on the upper Kantishna River. Like the tag deployment wheels, recovery wheels were inspected daily and adjusted as necessary. All chum salmon were enumerated by sex. The color and identification numbers of all recaptured tags were recorded. All chum salmon not bearing tags were examined for the secondary mark, a right pelvic fin clip. Additionally, all chinook and coho salmon were enumerated by sex, while other species were enumerated daily. The ADF&G office in Fairbanks was contacted daily via satellite or cellular telephone to report summary data for the previous 24-hour catch. Tags were recovered on the Toklat and Delta Rivers by ADF&G personnel.

DATA ANALYSIS

Diagnostic Statistical Tests

Bailey's closed population model requires the following assumptions: (1) there is no immigration, emigration, and mortality between the tagging and recovery sites; (2) all marked fish mix completely with unmarked fish; and (3) all fish have an equal probability of recapture. These conditions were examined before estimating abundance.

While mortality induced by tagging and handling is unknown, a mortality rate of 5% has been used in all years of the study. This number is similar to the 5.2% of radio-tagged fall chum salmon in the Tanana River that did not proceed upstream (Barton 1992). For the analysis, the number of tags deployed was decreased by 5% prior to use in the abundance estimate.

Data Reduction and Adjustment

The numbers of marked and unmarked fish were adjusted using the distribution of travel times for marked fish. This adjustment was necessary because some unmarked fish were between tagging and recovery fish wheels when the study began (18-25 August for the Tanana River, 16-27 August for the Kantishna-Toklat Rivers), and some marked fish would not reach the recovery wheel when the study ended (27 September – 2 October for the Tanana, 22-28 September for the Kantishna-Toklat). For each day the number of unmarked fish was multiplied by the appropriate cumulative proportion, which resulted in a final vector of the daily number of unmarked fish captured in the recovery fish wheels (Tables 2 through 5). We assumed that the distribution of

travel times of marked fish was an accurate representation of the distribution of travel times of unmarked fish, though it should be noted that traveling times of marked fish could differ from that of unmarked fish.

To examine the assumption of complete mixture of marked and unmarked fish, the following assumptions were tested: equal travel time from release to recapture sites between day fish and night fish; and equal recapture rate (i.e., marked-unmarked ratio) between left and right bank fish wheels, between Toklat and Kantishna recapture sites, and across time period. The Kolmogorov-Smirnov test was employed to examine equality of travel time (days) from release to recapture sites between day fish and night fish. Chi-square tests were used to test for equal recapture rates between left and right bank fish wheels at the Toklat and Kantishna recapture sites, for proportion of recaptures between day and night chum salmon and to test for equal recapture rates across weeks. Finally, to examine the assumption that all fish have an equal probability of recapture, logistic regression was utilized in which fish of marked (0) and recaptured (1) were regressed with sex and size.

Abundance Estimation

When null hypotheses of all the above tests were not rejected at p = 0.05 critical region, the data were combined and Bailey's modified Peterson estimate was employed to estimate the total run size of the Tanana and Kantishna Rivers.

Bailey's estimation equation is:

$$\hat{N} = \frac{(C+1)(M)}{R+1} \qquad \{1\}$$

$$V\left[\hat{N}\right] \cong \frac{M^2(C+1)(C-R)}{(R+1)^2(R+2)} \qquad \{2\}$$

Where:

$\hat{N}$ = Total run estimate.

M = The number of fish tagged and released at the tagging fish wheels.

C = The number of fish caught at the recovery fish wheels.

R = The number of tagged fish recaptured at the recovery fish wheels.

When the equal recapture rate for size or sex is violated, the data will be stratified by size and sex, and estimation will be conducted separately for each strata. When the complete mixture assumption is violated, Darroch's (1961) estimation method will be used. However, Darroch's (1961) method employs a maximum-likelihood estimation technique that requires abundant recapture data to stabilize the estimation. Thus, when recapture data is not sufficient, even though the complete mixture assumption is violated, Darroch's (1961) method will not be used.

Migration Rate

Migration rate between the tagging and recovery fish wheels was calculated as

$$\hat{M} = \frac{RD}{D} \qquad \{3\}$$

Where:

RD= Distance between tagging fish wheel and recovery wheel (76 km on the Tanana River, 113 km on the Kantishna River to the Toklat recovery fish wheels, and 139 km from the Kantishna tagging wheel to the upper Kantishna recovery wheel).

D = Number of days taken for a tagged fish to be recaptured at the recovery wheel.

Stock Timing

ADF&G personnel conducted ground survey counts of the Delta and Toklat Rivers, and the number of live and dead chum and coho salmon were enumerated. On the Delta River, eight surveys were conducted from 3 October through 27 November. On the Toklat River, surveys were conducted 9 through 15 October. USGS personnel conducted ground surveys through August and September on Bluff Cabin Slough on the upper Tanana River. In all locations tags were retrieved when they were present.

RESULTS

The 2000 season was characterized by extreme high water conditions on the Tanana River because of heavy rainfall during the month of August and September. Water level was well above the 1987-1999 average (Figure 3). Consequently, tag deployment and recovery began on 18 August, which is 2 days behind the schedule date (August 16). Tag deployment on the Kantishna River was not affected by high water, and tag deployment began as scheduled. The recovery wheel on the upper Kantishna River began operation on schedule. However, tag recovery on the Toklat River was affected by high water, and operations began late. The catch-per-unit-effort (CPUE) at the Tanana River tagging wheel was low until approximately the first week in September when CPUE began to increase markedly, which has been the precedent for all years of the project (Figure 4).

SAMPLING

Tag Deployment

At the Tanana River tagging wheel, a total of 1,922 fall chum salmon tags were deployed of which 1,065 were day fish and 857 were night fish (Appendix A). The peak chum salmon catch CPUE 4.50, (catch per unit effort, number of chum salmon captured per hour) occurred on 12 September on the Tanana River (Figures 4, 5). A total of 127 chum salmon were not tagged largely because of injuries that might have affected their swimming ability, death in the live-box or escape. At the Kantishna River tagging wheel, a total of 970 chum salmon tags were deployed of which 612 were day fish and 358 were night fish (Appendix B). The peak chum salmon catch occurred on 22 August (CPUE 2.83) (Figure 4). A total of 31 chum salmon were not tagged for the same reasons as above.

Tag Recovery

At the Tanana River recovery fish wheel, a total of 1,199 chum salmon were examined for marks of which 3.7% (45) were tagged (Appendix A). In the Toklat River recovery fish wheels, 822 chum salmon were examined of which 4.3% (35) were tagged (Appendices A and E). One chum salmon recaptured at the Toklat recovery fish wheels was tagged at the Tanana tagging wheel. In the upper Kantishna River recovery fish wheels, 305 chum salmon were examined of which 3.6% (11) were tagged (Appendix F). No tag loss was detected on either the Tanana or Kantishna Rivers. A total of 143 chum salmon tags were returned from various sources of which most (45) were recovered from the Tanana River recovery fish wheels. One chum salmon tagged in the Tanana River on 13 September was captured near the mouth of the Koyukuk River on 29 September (Table 6). Chum salmon tags were also recovered during foot surveys on the Delta and Toklat Rivers. On the Delta River, 16 tags were recovered from seven foot surveys, while 35 tags (including one tag that was deployed in 1999) were recovered from foot surveys on the Toklat River springs from 11 through 16 October.

DATA ANALYSIS

Migration rate

The Tanana River mean migration rate for day tagged fish was 25 km/day (n = 25) and 20 km/day (n = 20) for night tagged fish with a combined mean of 23 km/day. These rates are similar to previous years: 29.6 km/day in 1998, 21 km/day in 1997, and 24 km/day in 1999. The chum salmon captured at the Tanana River tagging fish wheel required a maximum of 8 days to

migrate to the Tanana recovery fish wheel. Approximately 78% of the tagged chum salmon required 1-4 days to migrate to the recovery wheel, while the remaining 22% required 5-8 days (Table 2).

The migration rate between the Kantishna River tagging wheel and the Toklat River recovery fish wheels was 25 km/day (n = 24) for day fish and 29 km/day (n = 9) for night fish with a combined mean of 26 km/day. The migration rate between the Kantishna River tagging fish wheel and the upper Kantishna River recovery fish wheel was 26 km/day (n = 10) for day fish and 27 km/day (n = 1) for night fish with a combined mean of 26 km/day. Approximately 90% of the fish required 2-6 days to migrate to the recovery fish wheels, however one fish (not included) required 29 days to migrate to the recovery fish wheels (Table 3).

Diagnostic Statistical Tests

The Kolmogorov-Smirnov (KS) test showed no significant difference in the migration rate between day and night fish captured in the Tanana River (D = 0.16, df 45, P>0.05) and Toklat River (D = 0.20, df 23, P>0.05) recovery fish wheels. On the other hand, a significant difference was found in the upper Kantishna (D = 0.4, df 11, P< 0.05); however, this is close to the D = 0.391 for P = 0.05. Further, only one night fish was recaptured compared to 10 day fish. Accordingly, we consider no significant difference in capture probability between the two. Chi-square tests showed no significant difference of recapture rates between left and right bank fish wheels on the Toklat River (Chi-square 0.00005, df 1, P = 0.994), between the Toklat and Kantishna recapture sites (Chi-square 0.00197, df 1, P = 0.965), for day and night fish on the Tanana River (Chi-square 1.718, df 1, P = 0.895) and on the Toklat River (Chi-square 2.373, df 1, P = 0.123), and across weeks in the Tanana River (Chi-square = 3.068, df 3, P = 0.381), Toklat River (Chi-square = 2.669, df 3, P =0.445), and Kantishna River (Chi-square = 6.755, df 3, P =0.080). Goodness of fit test of multiple logistic regression models with predictor variables of size and sex showed significant difference between model prediction and actual data (Hosmer-Lemeshow test P < 0.001) for the Tanana, Kantishna, and Toklat Rivers. These tests indicate that all assumptions were met, therefore Bailey's method was used for the abundance estimate.

Abundance Estimate

The final population estimate using Bailey's closed-population model was 34,844 (SE 4,970) fall chum salmon for the Tanana River with 95% confidence interval (25,104; 44,584) and coefficient of variation approximately 0.14, and 21,450 (SE 3,031) fall chum salmon for the Kantishna River with 95% confidence interval (15,510; 27,390) and coefficient of variation approximately 0.14 (Tables 7, 8, Figure 6).

No commercial chum salmon fishery occurred in Subdistricts 6-B and 6-C in 2000, and the preliminary subsistence harvest estimate was approximately 311 fall chum salmon (Borba and

Hamner 2001). This leaves an estimated spawning escapement to the upper Tanana River in 1995-1999 ranging from 183,267 to 50,100 fall chum salmon.

Stock Timing

Sixteen chum salmon tags were recovered during surveys of spawning grounds in the Delta River between 3 October and 27 October 2000 (Table 6). The median tag deployment date was 30 August, and tagging dates ranged from 22 August through 25 September. The median tag deployment date for tags recovered in the Delta River was 14 September in 1995, 1996 and 1997, 27 September in 1998, and 20 September in 1999. The absolute number of tags recovered in 1995-1999 was 39, 183, 26, 55, and 128 respectively. Thirty-five fall chum salmon tags were recovered from the Toklat River spawning grounds during surveys conducted 10 through 16 October, including one tag deployed in 1999 that was recovered from Geiger Creek.

DISCUSSION

The 2000 run could be characterized as poor. The 2000 Tanana River estimated escapement of 46,593 fall chum salmon is only 31% of the 1974-1999 average escapement of 147,640 (Eggers 2001) and is the lowest estimate since inception of the project (Table 9, Figure 7). This poor return was also reported at Pilot Station as the Yukon River sonar fall chum salmon estimate of 253,512, the lowest fall chum estimate since the project's inception, which has a 510,297 historical (1997-1999) season average (Rich 2001). Further, the ADF&G test fish wheel located on the left bank of the Yukon River near the village of Tanana caught 2,581 fall chum salmon which is approximately 16% of its 1994-1999 average annual catch. Finally, 2000 spawning ground surveys in the Toklat River revealed an escapement of 5,000 which is only 15% of the minimum escapement goal of 33,000, and one of the lowest escapements on record. Other indications of poor run strength in 2000 include the Delta River escapement (based on foot survey counts) of 3,777 (Bergstrom et. al 2000) and the Toklat River springs escapement of 5,095 (aerial survey estimate). Aerial surveys of the Bearpaw River area (a tributary to the Kantishna River) were not completed because of heavy fog by the National Park Service (NPS) in late September however only small numbers of spawning chum salmon were observed in the streams surveyed in the vicinity (Fred Andersen, NPS employee, personal communication). In view of the fact that the 95% confidence interval for the abundance estimate on the Kantishna River is 15,510-27,390, it is possible that the escapement on the Kantishna River may have been near the lower bound of the confidence interval.

RECOMMENDATIONS

Efforts should be made to minimize injury to captured salmon by modifying fish wheels to include padding on the fish wheel baskets and live boxes. Model development efforts should continue in order to provide more refined inseason and postseason tools for abundance estimation. Other data analysis tools should be explored and developed to test as many assumptions as possible. We also recommend that day and night fish continue to be tagged to increase sample size when possible. Pooling data from day and night fish can substantially increase the number of marked fish, which significantly reduces the variance of the abundance estimate. Day and night fish should be pooled only after tests are performed to verify that no differences exist between them. However, based on results from 1999-2000, tagging fish that are held in a live-box overnight for up to 12 hours does not have a detectable effect on their probability of recapture when the number of fish in the live-box is low. Therefore, it may not be necessary to separate and track day and night fish, especially in years of low abundance.

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Table 1. Abundance estimates using the Bailey model for fall chum salmon in the Tanana and Kantishna Rivers, 2000.

Tanana River

Date	Point Estimate	S.E.	95% Lower Bound	95% Upper Bound	CV
9/11/00	20,826	4,090	12,810	28,842	0.19
9/24/00	43,277	6,634	30,274	56,280	0.15
10/2/00	47,635	6,814	34,280	60,990	0.14

Kantishna River

Date	Point Estimate	S.E.	95% Lower Bound	95% Upper Bound	CV
9/11/00	11,059	3,247	4,695	17,423	0.29
9/24/00	22,217	3,846	14,679	26,775	0.17
9/28/00	21,104	3,393	14,454	27,754	0.16

Table 2. Counts and cumulative proportions of travel time between tag deployment and recovery fish wheels on the Tanana River used in the data reduction for the Bailey estimator, 2000.

Travel Time (days)	Day Tag Count	Day Tag Cumulative Proportion	Night Tag Count	Night Tag Cumulative Proportion	Combined Count	Combined Cumulative Proportion
0	0	0.00	0	0.00	0	0.00
1	0	0.00	1	0.04	1	0.02
2	4	0.20	6	0.28	10	0.24
3	7	0.55	7	0.56	14	0.56
4	6	0.85	4	0.72	10	0.78
5	3	1.00	3	0.84	6	0.91
6	0	1.00	3	0.96	3	0.98
7	0	1.00	0	0.96	0	0.98
8	0	1.00	1	1.00	1	1.00
Total	20		25		45	

Table 3. Counts and cumulative proportions of travel time between tag deployment wheel on the Kantishna River and recovery fish wheels on the Toklat River and Kantishna River used in the data reduction for the Bailey estimator, 2000.

Travel Time (days)	Day Tag Count	Day Tag Cumulative Proportion	Night Tag Count	Night Tag Cumulative Proportion	Combined Count	Combined Cumulative Proportion
0	0	0.00	0	0.00	0	0.00
1	0	0.00	0	0.00	0	0.00
2	0	0.00	1	0.10	1	0.02
3	3	0.09	2	0.30	5	0.14
4	10	0.38	1	0.40	11	0.39
5	10	0.68	4	0.80	14	0.70
6	9	0.94	2	1.00	11	0.95
7	0	0.94	0	1.00	0	0.95
8	0	0.94	0	1.00	0	0.95
9	1	0.97	0	1.00	1	0.98
10	0	0.97	0	1.00	0	0.98
11	0	0.97	0	1.00	0	0.98
12	1	1.00	0	1.00	1	1.00
Total	34		10		44	

Table 4. Observed and adjusted number of releases at the tag deployment wheel and observed and adjusted number of unmarked catches at the recovery wheel used in the Bailey model to estimate the abundance of fall chum salmon in the Tanana River, 2000.

Date	Day Tags Released	Estimated Proportion Passing Recovery Wheels	Night Tags Released	Estimated Proportion Passing Recovery Wheels	Adjusted Tags Released	Unmarked Catch	Estimated Proportion Passing Tagging Wheel	Adjusted Unmarked Catch	Adjusted Cum Tags Released	Cum Catch Unmarked
8/16										
8/17										
8/18	0	0.95	6	0.95	6	5	0.00	0	6	0
8/19	5	0.95	8	0.95	12	6	0.02	0	18	0
8/20	10	0.95	13	0.95	22	13	0.24	3	40	3
8/21	27	0.95	30	0.95	54	13	0.56	7	94	11
8/22	36	0.95	37	0.95	69	12	0.78	9	163	20
8/23	28	0.95	60	0.95	84	21	0.91	19	247	39
8/24	30	0.95	33	0.95	60	19	0.98	19	307	58
8/25	23	0.95	17	0.95	38	33	0.98	32	345	90
8/26	18	0.95	18	0.95	34	37	1.00	37	379	127
8/27	15	0.95	18	0.95	31	56	1.00	56	410	183
8/28	19	0.95	12	0.95	29	49	1.00	49	440	232
8/29	12	0.95	1	0.95	12	31	1.00	31	452	263
8/30	4	0.95	5	0.95	9	32	1.00	32	461	295
8/31	10	0.95	6	0.95	15	36	1.00	36	476	331
9/1	7	0.95	7	0.95	13	34	1.00	34	489	365
9/2	9	0.95	8	0.95	16	35	1.00	35	505	400
9/3	7	0.95	9	0.95	15	52	1.00	52	521	452
9/4	20	0.95	9	0.95	28	28	1.00	28	548	480
9/5	0	0.95	10	0.95	10	10	1.00	10	558	490
9/6	17	0.95	8	0.95	24	10	1.00	10	581	500
9/7	10	0.95	4	0.95	13	0	1.00	0	595	500
9/8	12	0.95	5	0.95	16	47	1.00	47	611	547
9/9	22	0.95	13	0.95	33	35	1.00	35	644	582
9/10	36	0.95	22	0.95	55	12	1.00	12	699	594
9/11	24	0.95	25	0.95	47	20	1.00	20	746	614
9/12	65	0.95	34	0.95	94	16	1.00	16	840	630
9/13	54	0.95	33	0.95	83	4	1.00	4	922	634
9/14	62	0.95	35	0.95	92	16	1.00	16	1015	650
9/15	51	0.95	48	0.95	94	5	1.00	5	1109	655
9/16	47	0.95	29	0.95	72	34	1.00	34	1181	689
9/17	45	0.95	32	0.95	73	25	1.00	25	1254	714
9/18	44	0.95	27	0.95	67	8	1.00	8	1321	722
9/19	43	0.95	24	0.95	64	68	1.00	68	1385	790
9/20	27	0.95	16	0.95	41	59	1.00	59	1426	849
9/21	30	0.95	12	0.95	40	50	1.00	50	1466	899
9/22	24	0.95	12	0.95	34	63	1.00	63	1500	962
9/23	19	0.95	15	0.95	32	42	1.00	42	1532	1004
9/24	19	0.95	29	0.95	46	26	1.00	26	1578	1030
9/25	27	0.95	31	0.91	54	14	1.00	14	1632	1044
9/26	38	0.95	25	0.91	59	8	1.00	8	1691	1052
9/27	32	0.95	29	0.80	54	25	1.00	25	1744	1077
9/28	18	0.81	23	0.68	30	15	1.00	15	1775	1092
9/29	19	0.52	19	0.53	20	10	1.00	10	1795	1102
9/30	0	0.19	0	0.27	0	20	1.00	20	1795	1122
10/1	0	0.00	0	0.04	0	5	1.00	5	1795	1127
10/2	0	0.00	0	0.00	0	0	1.00	0	1795	1127

Table 5. Observed and adjusted number of releases at the tag deployment wheel and observed and adjusted number of unmarked catches at the recovery wheel used in the Bailey model to estimate the abundance of fall chum salmon in the Kantishna River, 2000.

Date	Day Tags Released	Estimated Proportion Passing Recovery Wheels	Night Tags Released	Estimated Proportion Passing Recovery Wheels	Adjusted Tags Released	**Toklat** Unmarked Catch	Toklat Estimated Proportion Passing Tagging Wheel	Toklat Adjusted Unmarked Catch	**Kantishna** Unmarked Catch	Kantishna Estimated Proportion Passing Tagging Wheel
8/16	2	0.95	4	0.95	6	0	0.00	0	2	0.00
8/17	7	0.95	0	0.95	7	0	0.00	0	2	0.00
8/18	3	0.95	5	0.95	8	0	0.00	0	3	0.00
8/19	6	0.95	12	0.95	17	0	0.00	0	1	0.00
8/20	15	0.95	14	0.95	28	0	0.00	0	2	0.00
8/21	11	0.95	15	0.95	25	2	0.00	0	2	0.00
8/22	31	0.95	36	0.95	64	0	0.00	0	1	0.00
8/23	14	0.95	8	0.95	21	1	0.00	0	4	1.00
8/24	16	0.95	13	0.95	28	2	0.00	0	0	1.00
8/25	19	0.95	5	0.95	23	2	0.00	0	3	1.00
8/26	21	0.95	7	0.95	27	2	0.00	0	0	1.00
8/27	8	0.95	10	0.95	17	11	0.00	0	7	1.00
8/28	4	0.95	8	0.95	11	25	0.00	0	7	1.00
8/29	6	0.95	4	0.95	10	13	1.00	13	9	1.00
8/30	7	0.95	2	0.95	9	10	1.00	10	3	1.00
8/31	2	0.95	8	0.95	10	5	1.00	5	3	1.00
9/1	18	0.95	12	0.95	29	10	1.00	10	3	1.00
9/2	10	0.95	3	0.95	12	7	1.00	7	3	1.00
9/3	15	0.95	10	0.95	24	5	1.00	5	2	1.00
9/4	4	0.95	5	0.95	9	5	1.00	5	9	1.00
9/5	18	0.95	6	0.95	23	6	1.00	6	1	1.00
9/6	9	0.95	8	0.95	16	17	1.00	17	6	1.00
9/7	15	0.95	10	0.95	24	10	1.00	10	0	1.00
9/8	23	0.95	12	0.95	33	6	1.00	6	9	1.00
9/9	19	0.95	14	0.95	31	17	1.00	17	7	1.00
9/10	22	0.95	14	0.95	34	20	1.00	20	5	1.00
9/11	25	0.95	8	0.95	31	16	1.00	16	11	1.00
9/12	26	0.95	10	0.95	34	26	1.00	26	11	1.00
9/13	19	0.95	8	0.95	26	26	1.00	26	9	1.00
9/14	23	0.95	11	0.95	32	37	1.00	37	13	1.00
9/15	26	0.95	12	0.95	36	56	1.00	56	16	1.00
9/16	32	0.00	2	0.00	0	46	1.00	46	8	1.00
9/17	18	0.00	7	0.00	0	41	1.00	41	11	1.00
9/18	17	0.00	8	0.00	0	45	1.00	45	15	1.00
9/19	18	0.00	14	0.00	0	70	1.00	70	14	1.00
9/20	15	0.00	9	0.00	0	57	1.00	57	10	1.00
9/21	17	0.00	7	0.00	0	49	1.00	49	24	1.00
9/22	16	0.00	5	0.00	0	48	1.00	48	19	1.00
9/23	14	1.90	8	0.00	27	26	1.00	26	8	1.00
9/24	10	3.80	4	0.00	38	36	1.00	36	3	1.00
9/25	11	0.95	0	0.00	10	37	1.00	37	5	1.00
9/26	0	1.90	0	0.00	0	19	1.00	19	5	1.00
9/27	0	0.95	0	0.00	0	10	1.00	10	4	1.00
9/28	0	0.00	0	0.00	0	2	1.00	2	4	1.00

Table 6. Number of tags returned by location from fall chum salmon tagged in the Tanana and Kantishna Rivers, 2000.

Recapture Location	Number of Tags
Delta River	16
Tanana River recovery wheels	45
Toklat River recovery wheels	35
Toklat Springs	34
Kantishna River	11
Seventeen Mile Slough	1
Mouth of the Koyukuk River	1
Total	143

Table 7. Daily and cumulative catch statistics and Bailey abundance estimates of fall chum salmon in the Tanana River, 2000.

Date	Adjusted (Releases)	Examined For Tags	Recaptures	Abundance	95% Confidence Bounds Lower	95% Confidence Bounds Upper	Standard Error	CV
8/16								
8/17								
8/18	6	0	0					
8/19	12	0	0					
8/20	22	3	0					
8/21	54	7	0					
8/22	69	9	0					
8/23	84	19	0					
8/24	60	20	1					
8/25	38	34	2					
8/26	34	42	5					
8/27	31	66	10	2,500	1,207	3,793	660	0.26
8/28	29	62	13	3,739	1,962	5,516	907	0.24
8/29	12	47	16	4,070	2,297	5,843	904	0.22
8/30	9	51	19	4,331	2,580	6,082	893	0.21
8/31	15	55	19	5,331	3,155	7,507	1,110	0.21
9/1	13	53	19	6,311	3,718	8,904	1,323	0.21
9/2	16	55	20	7,076	4,227	9,925	1,454	0.21
9/3	15	74	22	7,877	4,832	10,922	1,554	0.20
9/4	28	50	22	8,961	5,487	12,435	1,772	0.20
9/5	10	32	22	9,359	5,728	12,990	1,853	0.20
9/6	24	32	22	10,010	6,123	13,897	1,983	0.20
9/7	13	22	22	10,239	6,263	14,215	2,028	0.20
9/8	16	69	22	11,766	7,183	16,349	2,338	0.20
9/9	33	58	23	12,855	7,944	17,766	2,506	0.19
9/10	55	35	23	14,304	8,835	19,773	2,790	0.20
9/11	47	43	23	15,878	9,802	21,954	3,100	0.20
9/12	94	40	24	17,737	11,083	24,391	3,395	0.19
9/13	83	28	24	19,630	12,264	26,996	3,758	0.19
9/14	92	40	24	22,240	13,888	30,592	4,261	0.19
9/15	94	29	24	24,523	15,312	33,734	4,699	0.19
9/16	72	60	26	25,760	16,440	35,080	4,755	0.18
9/17	73	53	28	26,637	17,332	35,942	4,747	0.18
9/18	67	36	28	28,434	18,498	38,370	5,069	0.18
9/19	64	96	28	33,051	21,474	44,628	5,907	0.18
9/20	41	87	28	36,927	23,970	49,884	6,610	0.18
9/21	40	81	31	36,829	24,516	49,142	6,282	0.17
9/22	34	98	35	36,293	24,843	47,743	5,842	0.16
9/23	32	80	38	35,991	25,077	46,905	5,568	0.15
9/24	46	65	39	36,125	25,304	46,946	5,521	0.15
9/25	54	54	40	35,805	25,211	46,399	5,405	0.15
9/26	59	48	40	36,104	25,419	46,789	5,451	0.15
9/27	54	66	41	36,193	25,607	46,779	5,401	0.15
9/28	30	57	42	35,921	25,536	46,306	5,299	0.15
9/29	20	53	43	35,488	25,346	45,630	5,175	0.15
9/30	0	65	45	34,678	24,985	44,371	4,945	0.14
10/1	0	50	45	34,844	25,104	44,584	4,970	0.14
10/2	0	45	45	34,844	25,104	44,584	4,970	0.14

a The number of tags deployed was adjusted for a 5% mortality.

Table 8. Daily and cumulative catch statistics and Bailey abundance estimates of fall chum salmon in the Kantishna River, 2000.

Date	Adjusted (Releases)	Examined For Tags	Recaptures	Abundance	95% Confidence Bounds		Standard Error	CV
					Lower	Upper		
8/16	6	2	0					
8/17	7	2	0					
8/18	8	3	0					
8/19	17	1	0					
8/20	28	2	0					
8/21	25	4	0					
8/22	64	1	0					
8/23	21	5	0					
8/24	28	2	0					
8/25	23	5	1					
8/26	27	2	1					
8/27	17	18	1					
8/28	11	33	5	3,438	996	5,880	1,246	0.36
8/29	10	23	6	3,996	1,329	6,663	1,361	0.34
8/30	9	15	8	3,365	1,373	5,357	1,016	0.30
8/31	10	8	8	3,575	1,456	5,694	1,081	0.30
9/1	29	13	8	4,392	1,776	7,008	1,335	0.30
9/2	12	10	8	4,940	1,988	7,892	1,506	0.30
9/3	24	8	9	5,047	2,176	7,918	1,465	0.29
9/4	9	14	9	5,695	2,444	8,946	1,659	0.29
9/5	23	7	9	6,318	2,705	9,931	1,843	0.29
9/6	16	23	9	7,535	3,207	11,863	2,208	0.29
9/7	24	10	10	7,681	3,462	11,900	2,153	0.28
9/8	33	15	10	8,907	4,004	13,810	2,502	0.28
9/9	31	24	11	9,760	4,594	14,926	2,636	0.27
9/10	34	26	15	8,795	4,745	12,845	2,066	0.23
9/11	31	27	15	10,271	5,527	15,015	2,421	0.24
9/12	34	37	15	12,288	6,593	17,983	2,906	0.24
9/13	26	35	15	14,191	7,597	20,785	3,364	0.24
9/14	32	50	16	16,033	8,781	23,285	3,700	0.23
9/15	36	72	19	16,997	9,879	24,115	3,632	0.21
9/16	32	54	21	18,030	10,813	25,247	3,682	0.20
9/17	23	52	24	18,034	11,249	24,819	3,462	0.19
9/18	23	62	28	17,746	11,537	23,955	3,168	0.18
9/19	30	85	31	18,901	12,592	25,210	3,219	0.17
9/20	22	68	34	19,413	13,209	25,617	3,165	0.16
9/21	22	73	36	20,576	14,171	26,981	3,268	0.16
9/22	19	67	37	22,044	15,264	28,824	3,459	0.16
9/23	15	34	38	22,646	15,767	29,525	3,510	0.15
9/24	5	39	40	22,559	15,873	29,245	3,411	0.15
9/25	1	42	45	21,041	15,155	26,927	3,003	0.14
9/26	0	24	45	21,508	15,488	27,528	3,071	0.14
9/27	0	15	46	21,335	15,427	27,243	3,014	0.14
9/28	0	6	46	21,450	15,510	27,390	3,031	0.14

a The number of tags deployed was adjusted for a 5% mortality.

Table 9. Tanana and Kantishna River abundance estimates, using the Bailey model, 1995–2000.

Tanana River

Year	Point estimate	S.E.	95% Lower Bound	95% Upper bound
1995	268,173	21,597	225,842	310,503
1996	134,563	16,945	101,351	167,775
1997	71,661	11,876	48,384	94,937
1998	62,014	6,556	49,164	74,863
1999	97,843	19,362	59,893	135,792
2000	34,844	4,970	25,104	44,504

Kantishna River

Year	Point estimate	S.E.	95% Lower Bound	95% Upper bound
1999	27,199	3,562	20,218	34,180
2000	21,450	3,031	15,510	27,390

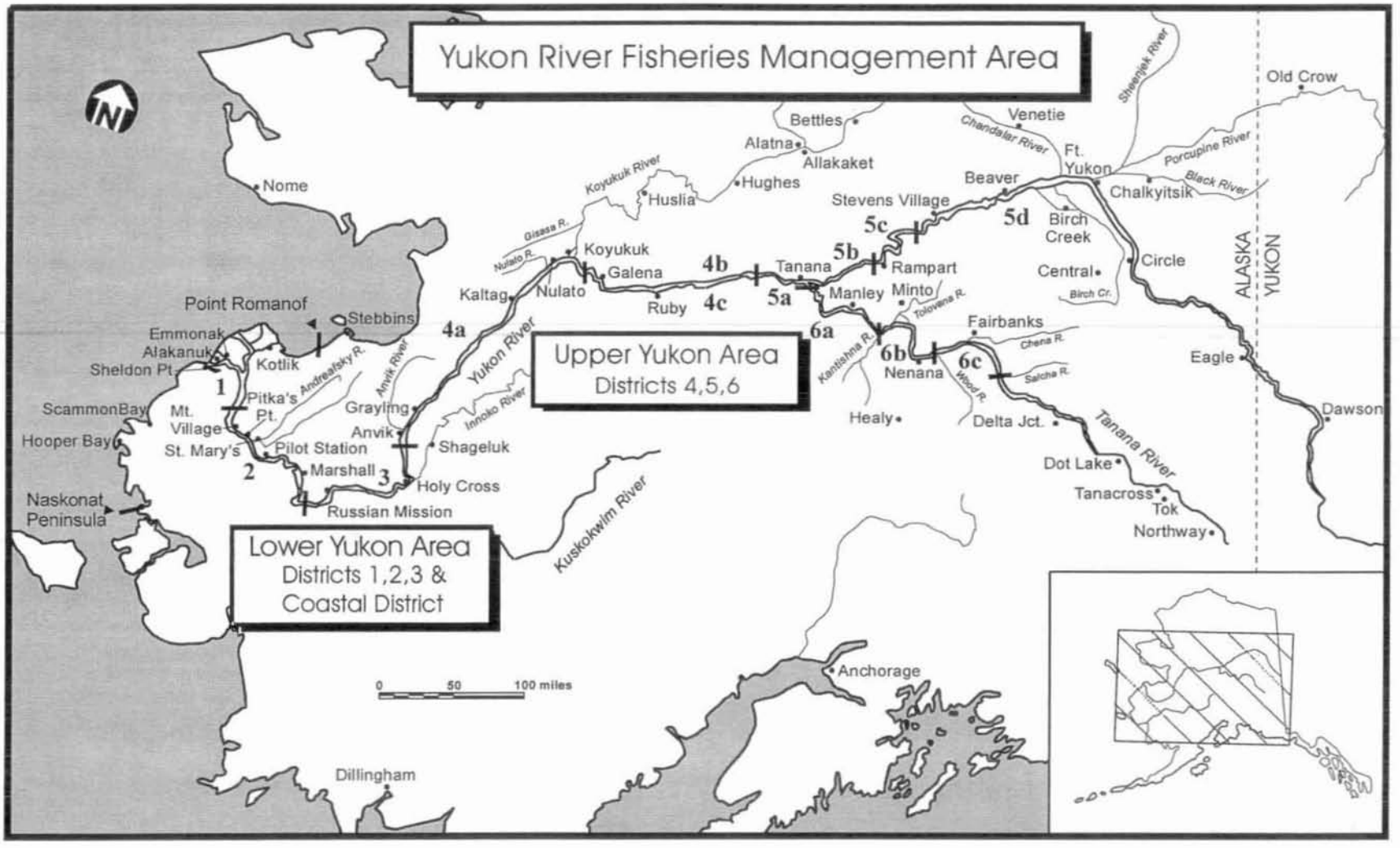


Figure 1. Fisheries management districts and subdistricts in the Yukon and Tanana River drainages.

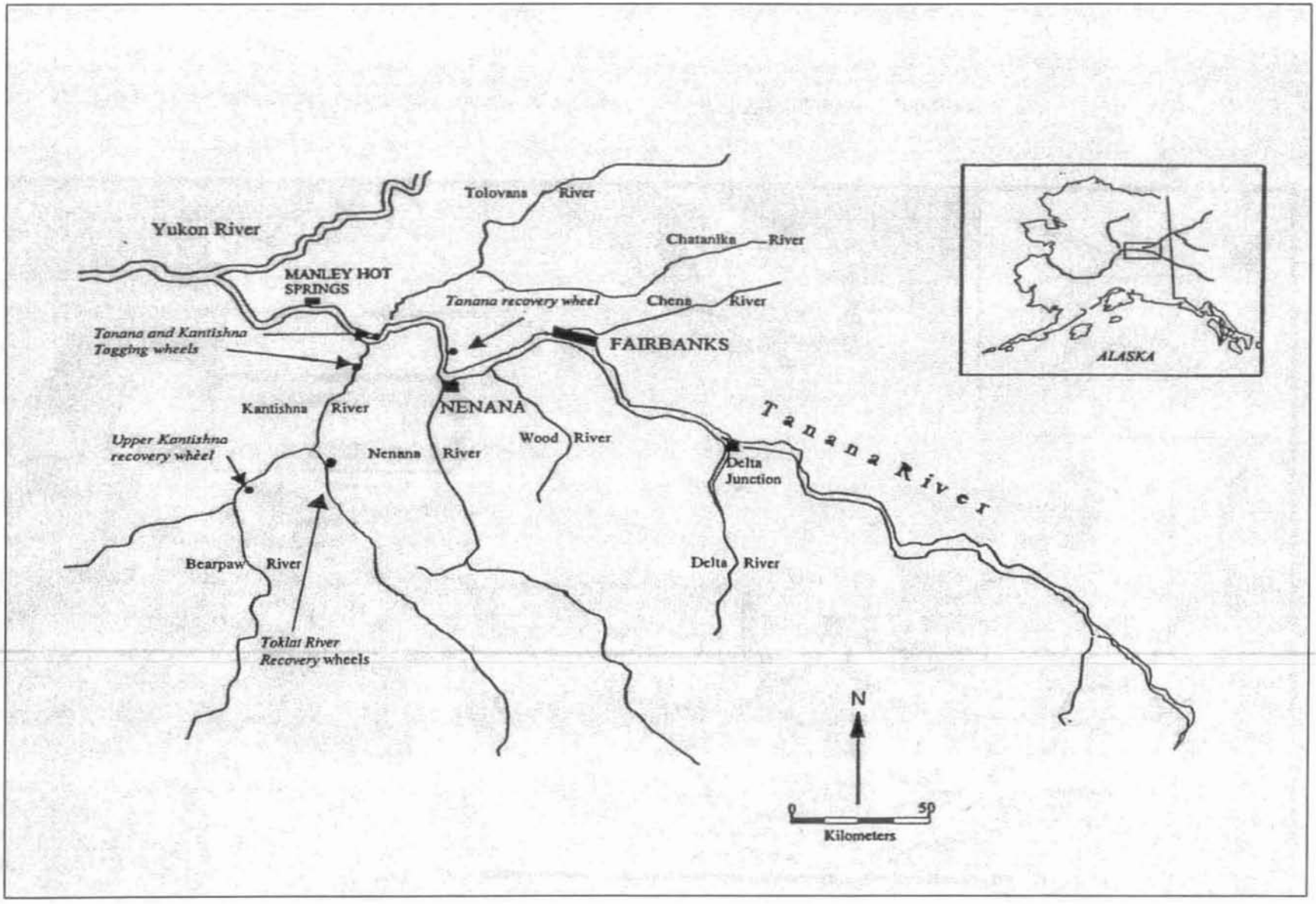


Figure 2. Location of tag deployment and recovery fish wheels used in the Tanana River fall chum tagging project.

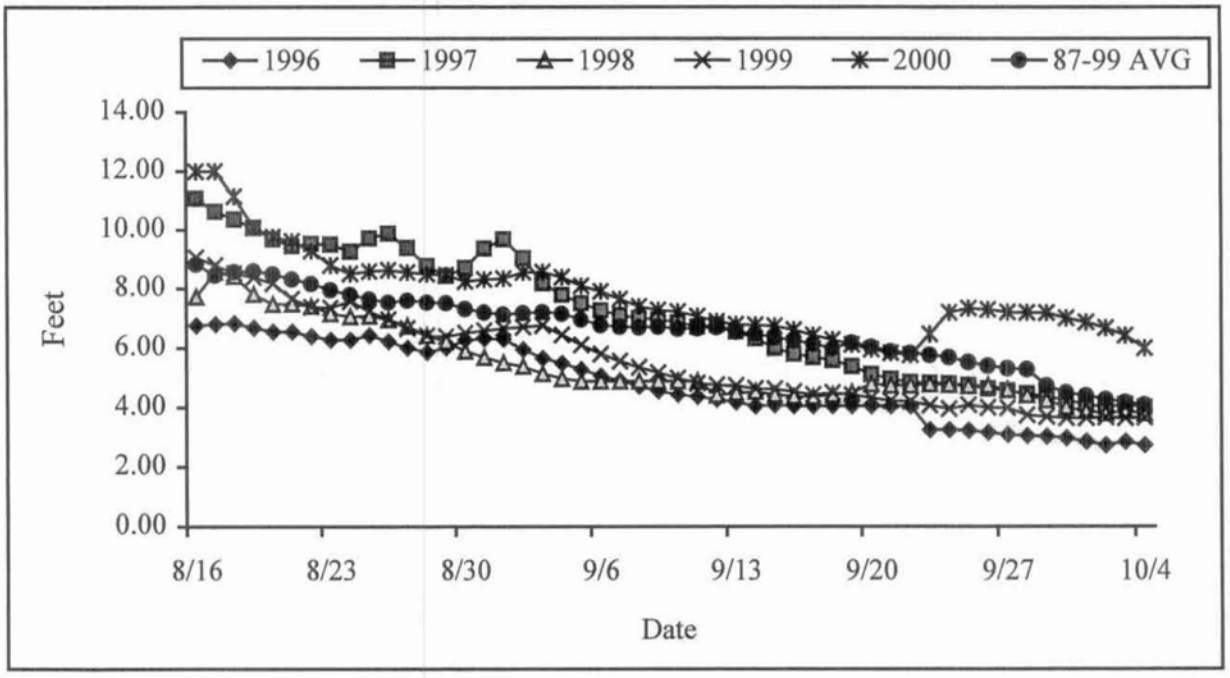
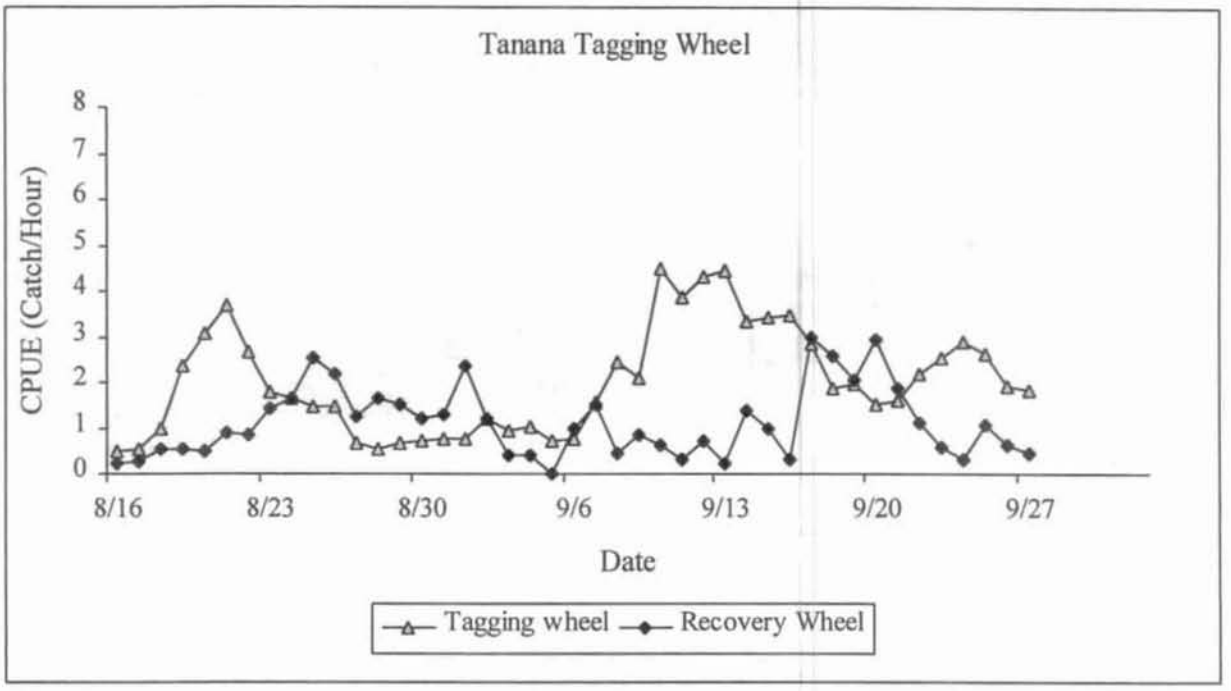


Figure 3. Daily water levels on the Tanana River as measured by a United States Geological Survey gauge located near Nenana, 1996-2000.



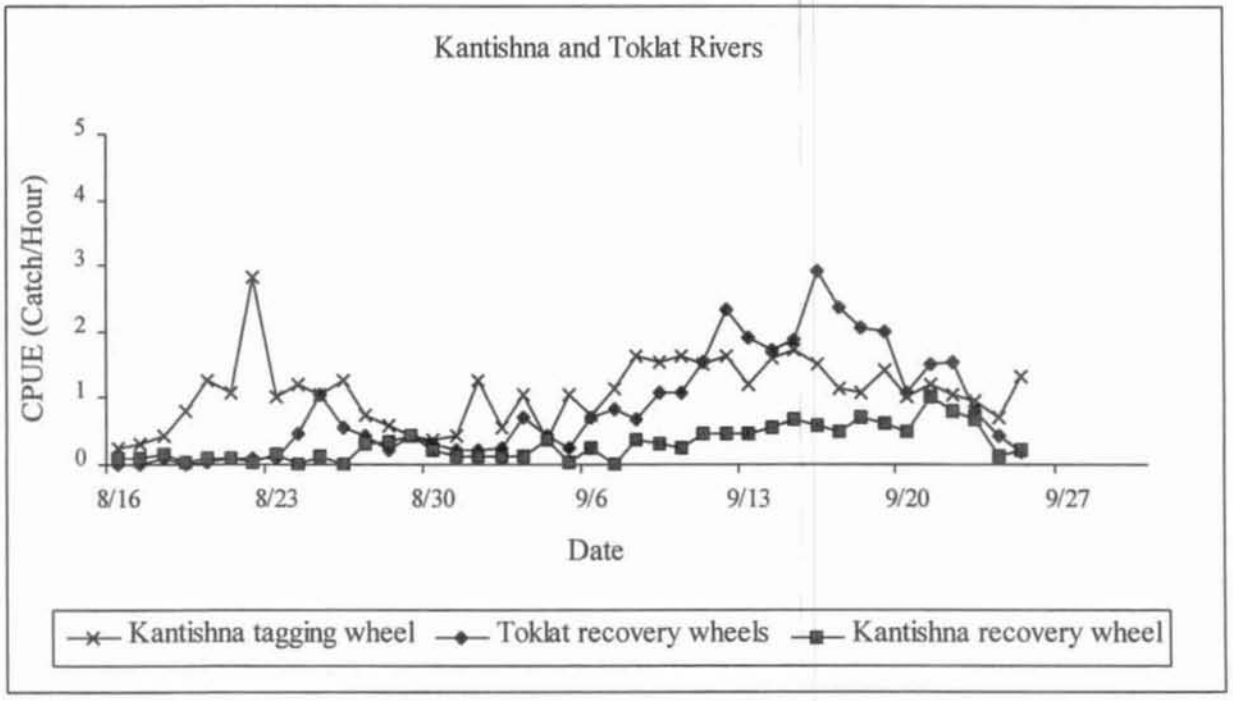
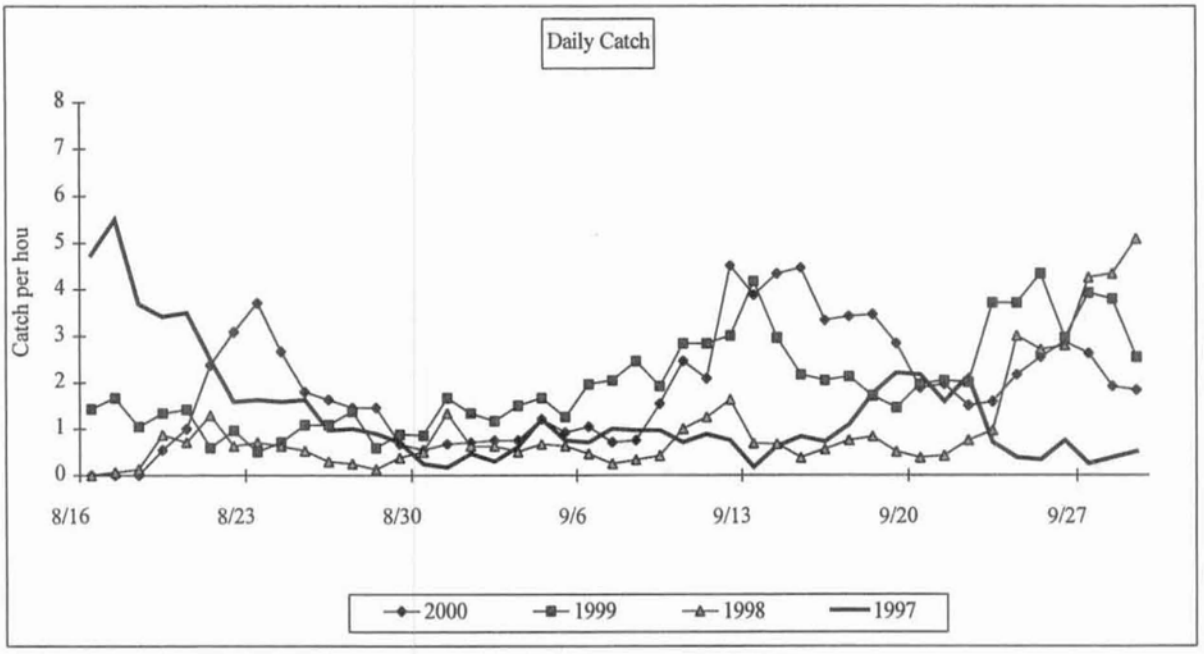


Figure 4. CPUE at the Tanana River tagging and recovery fish wheels (above), and CPUE at the Kantishna River tagging and recovery wheels and the recovery fish wheels on the Toklat River (below), 2000.



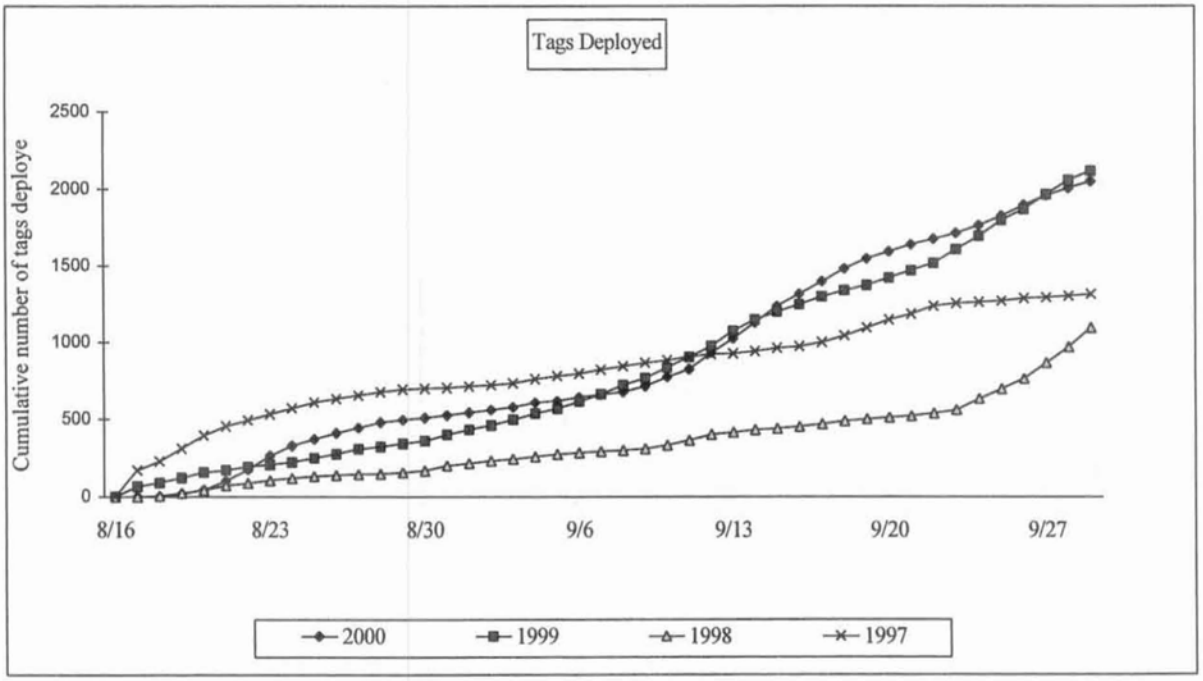


Figure 5. Daily CPUE at the Tanana tag deployment wheel (above) and the cumulative number of tags deployed at the Tanana tagging wheel (below), 1997-2000.

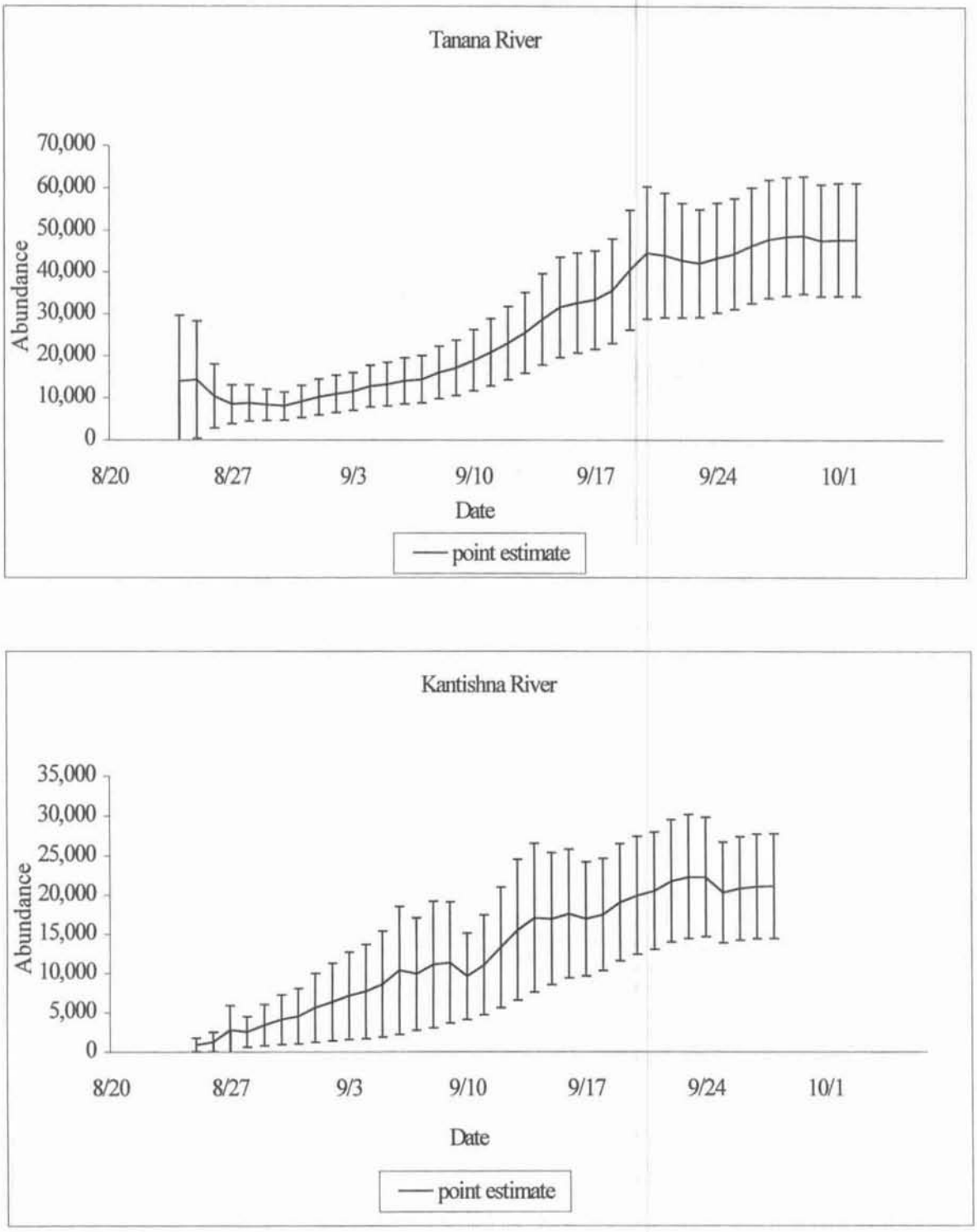


Figure 6. Abundance estimates and associated confidence bounds using the Bailey model for fall salmon tagged on the Tanana River (above) and Kantishna River (below).

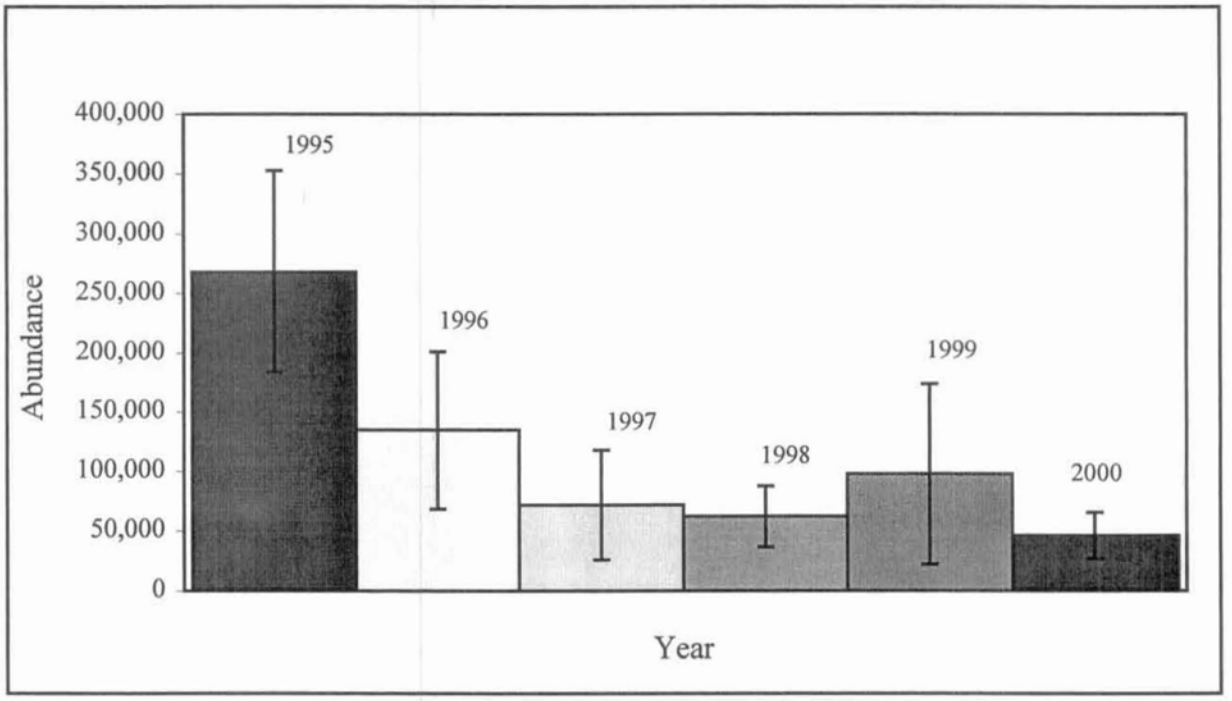


Figure 7. Abundance estimates and 95% confidence bounds for fall chum salmon on the Tanana River, 1995-2000.

Appendix A. Daily effort and catch of fall chum salmon in the Tanana River tagging fish wheel, 2000.

	Hours	Tagged				Not Tagged				Total			
Date	Fished	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative
8/16													
8/17													
8/18	12	1	5	6	6	0	0	0	0	1	5	6	6
8/19	24	5	8	13	19	0	0	0	0	5	8	13	19
8/20	24	4	19	23	42	1	0	1	1	5	19	24	43
8/21	24	15	42	57	99	0	0	0	1	15	42	57	100
8/22	24	34	39	73	172	1	0	1	2	35	39	74	174
8/23	24	33	55	88	260	0	1	1	3	33	56	89	263
8/24	24	24	39	63	323	0	1	1	4	24	40	64	327
8/25	24	14	26	40	363	2	1	3	7	16	27	43	370
8/26	24	18	18	36	399	2	1	3	10	20	19	39	409
8/27	24	18	15	33	432	2	0	2	12	20	15	35	444
8/28	24	20	11	31	463	2	2	4	16	22	13	35	479
8/29	24	8	5	13	476	0	3	3	19	8	8	16	495
8/30	24	5	4	9	485	1	3	4	23	6	7	13	508
8/31	24	10	6	16	501	0	0	0	23	10	6	16	524
9/1	24	9	5	14	515	1	2	3	26	10	7	17	541
9/2	24	9	8	17	532	0	1	1	27	9	9	18	559
9/3	24	9	7	16	548	2	0	2	29	11	7	18	577
9/4	24	12	17	29	577	0	0	0	29	12	17	29	606
9/5	12	5	5	10	587	1	0	1	30	6	5	11	617
9/6	24	12	13	25	612	0	0	0	30	12	13	25	642
9/7	24	5	9	14	626	0	3	3	33	5	12	17	659
9/8	24	7	10	17	643	0	1	1	34	7	11	18	677
9/9	24	18	17	35	678	1	1	2	36	19	18	37	714
9/10	24	28	30	58	736	0	1	1	37	28	31	59	773
9/11	24	22	27	49	785	0	1	1	38	22	28	50	823
9/12	24	52	47	99	884	5	4	9	47	57	51	108	931
9/13	24	47	40	87	971	2	4	6	53	49	44	93	1024
9/14	24	42	55	97	1068	2	5	7	60	44	60	104	1128
9/15	24	43	56	99	1167	5	3	8	68	48	59	107	1235
9/16	24	28	48	76	1243	0	4	4	72	28	52	80	1315
9/17	24	33	44	77	1320	2	3	5	77	35	47	82	1397
9/18	24	32	39	71	1391	3	9	12	89	35	48	83	1480
9/19	24	31	36	67	1458	0	1	1	90	31	37	68	1548
9/20	24	14	29	43	1501	2	0	2	92	16	29	45	1593
9/21	24	16	26	42	1543	0	5	5	97	16	31	47	1640
9/22	24	10	26	36	1579	0	0	0	97	10	26	36	1676
9/23	24	7	27	34	1613	2	2	4	101	9	29	38	1714
9/24	24	13	35	48	1661	3	1	4	105	16	36	52	1766
9/25	24	13	45	58	1719	2	1	3	108	15	46	61	1827
9/26	24	20	43	63	1782	2	4	6	114	22	47	69	1896
9/27	24	21	40	61	1843	1	1	2	116	22	41	63	1959
9/28	24	9	32	41	1884	2	3	5	121	11	35	46	2005
9/29	24	11	27	38	1922	3	3	6	127	14	30	44	2049
Total		787	1135	1922		52	75	127		839	1210	2049	

Appendix B. Daily effort and catch of fall chum salmon in the Kantishna River tagging wheel, 2000.

	Hours	Tagged				Not Tagged				Total			
Date	Fished	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative
8/16	24	1	5	6	6	0	0	0	0	1	5	6	6
8/17	24	4	3	7	13	0	0	0	0	4	3	7	13
8/18	24	3	5	8	21	1	1	2	2	4	6	10	23
8/19	24	13	5	18	39	1	0	1	3	14	5	19	42
8/20	24	24	5	29	68	0	1	1	4	24	6	30	72
8/21	24	15	11	26	94	0	0	0	4	15	11	26	98
8/22	24	40	27	67	161	0	1	1	5	40	28	68	166
8/23	24	15	7	22	183	2	0	2	7	17	7	24	190
8/24	24	23	6	29	212	0	0	0	7	23	6	29	219
8/25	24	19	5	24	236	1	0	1	8	20	5	25	244
8/26	24	19	9	28	264	1	1	2	10	20	10	30	274
8/27	24	14	4	18	282	0	0	0	10	14	4	18	292
8/28	24	8	4	12	294	1	1	2	12	9	5	14	306
8/29	24	9	1	10	304	0	0	0	12	9	1	10	316
8/30	24	9	0	9	313	0	0	0	12	9	0	9	325
8/31	24	9	1	10	323	0	0	0	12	9	1	10	335
9/1	24	21	9	30	353	0	0	0	12	21	9	30	365
9/2	24	9	4	13	366	0	0	0	12	9	4	13	378
9/3	24	14	11	25	391	0	0	0	12	14	11	25	403
9/4	24	7	2	9	400	0	0	0	12	7	2	9	412
9/5	24	18	6	24	424	1	0	1	13	19	6	25	437
9/6	24	14	3	17	441	0	1	1	14	14	4	18	455
9/7	24	21	4	25	466	1	1	2	16	22	5	27	482
9/8	24	24	11	35	501	3	1	4	20	27	12	39	521
9/9	24	22	11	33	534	1	3	4	24	23	14	37	558
9/10	24	28	8	36	570	0	3	3	27	28	11	39	597
9/11	24	28	5	33	603	2	1	3	30	30	6	36	633
9/12	24	24	12	36	639	0	3	3	33	24	15	39	672
9/13	24	19	8	27	666	1	1	2	35	20	9	29	701
9/14	24	24	10	34	700	2	2	4	39	26	12	38	739
9/15	24	26	12	38	738	3	0	3	42	29	12	41	780
9/16	24	18	16	34	772	1	1	2	44	19	17	36	816
9/17	24	17	8	25	797	1	1	2	46	18	9	27	843
9/18	24	19	6	25	822	1	0	1	47	20	6	26	869
9/19	24	26	6	32	854	0	2	2	49	26	8	34	903
9/20	24	19	5	24	878	0	0	0	49	19	5	24	927
9/21	24	15	9	24	902	5	0	5	54	20	9	29	956
9/22	24	14	7	21	923	4	0	4	58	18	7	25	981
9/23	24	16	6	22	945	1	0	1	59	17	6	23	1004
9/24	24	10	4	14	959	3	0	3	62	13	4	17	1021
9/25	9	7	4	11	970	0	1	1	63	7	5	12	1033
Total		685	285	970		37	26	63		722	311	1033	

Appendix C. Daily effort and catch of tagged and untagged fall chum salmon in the Tanana River recovery wheel,

	Hours	Tagged				Not Tagged				Total			
Date	Fished	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative
8/16													
8/17													
8/18	21	0	0	0	0	3	2	5	5	3	2	5	5
8/19	24	0	0	0	0	5	1	6	11	5	1	6	11
8/20	24	0	0	0	0	6	7	13	24	6	7	13	24
8/21	24	0	0	0	0	7	6	13	37	7	6	13	37
8/22	24	0	0	0	0	6	6	12	49	6	6	12	49
8/23	24	0	0	0	0	7	14	21	70	7	14	21	70
8/24	24	0	1	1	1	12	7	19	89	12	8	20	90
8/25	24	0	1	1	2	17	16	33	122	17	17	34	124
8/26	24	2	1	3	5	19	18	37	159	21	19	40	164
8/27	24	4	1	5	10	29	27	56	215	33	28	61	225
8/28	24	3	0	3	13	20	29	49	264	23	29	52	277
8/29	27	1	2	3	16	19	12	31	295	20	14	34	311
8/30	21	0	3	3	19	18	14	32	327	18	17	35	346
8/31	24	0	0	0	19	22	14	36	363	22	14	36	382
9/1	28	0	0	0	19	23	11	34	397	23	11	34	416
9/2	28	0	1	1	20	16	19	35	432	16	20	36	452
9/3	23	2	0	2	22	23	29	52	484	25	29	54	506
9/4	23.5	0	0	0	22	12	16	28	512	12	16	28	534
9/5	25	0	0	0	22	3	7	10	522	3	7	10	544
9/6	25	0	0	0	22	5	5	10	532	5	5	10	554
9/7	0	0	0	0	22	0	0	0	532	0	0	0	554
9/8	48	0	0	0	22	33	14	47	579	33	14	47	601
9/9	24	0	1	1	23	21	14	35	614	21	15	36	637
9/10	24	0	0	0	23	7	5	12	626	6	5	11	648
9/11	24	0	0	0	23	11	9	20	646	11	9	20	668
9/12	27	1	0	1	24	7	9	16	662	8	9	17	685
9/13	12	0	0	0	24	3	1	4	666	3	1	4	689
9/14	22	0	0	0	24	5	11	16	682	5	11	16	705
9/15	22	0	0	0	24	5	0	5	687	5	0	5	710
9/16	25	2	0	2	26	21	13	34	721	21	13	34	744
9/17	25	2	0	2	28	17	8	25	746	17	8	25	769
9/18	25	0	0	0	28	5	3	8	754	5	3	8	777
9/19	23	0	0	0	28	37	31	68	822	37	31	68	845
9/20	23	0	0	0	28	28	31	59	881	28	31	59	904
9/21	26	2	1	3	31	30	20	50	931	32	21	53	957
9/22	23	3	1	4	35	26	37	63	994	29	38	67	1024
9/23	24	1	2	3	38	15	27	42	1036	16	29	45	1069
9/24	24	1	0	1	39	11	15	26	1062	12	15	27	1096
9/25	25	1	0	1	40	3	11	14	1076	4	11	15	1111
9/26	25	0	0	0	40	4	4	8	1084	4	4	8	1119
9/27	24	0	1	1	41	10	15	25	1109	10	16	26	1145
9/28	25	1	0	1	42	3	12	15	1124	4	12	16	1161
9/29	24	1	0	1	43	1	9	10	1134	2	9	11	1172
9/30	24	2	0	2	45	7	13	20	1154	9	13	22	1194
10/1	24	0	0	0	45	1	4	5	1159	1	4	5	1199
10/2	24	0	0	0	45	0	0	0	1159	0	0	0	1199
Total		29	16	45		583	576	1159		607	592	1199	

Appendix D. Daily effort and catch of tagged and untagged fall chum salmon in the Toklat River right bank recovery fish wheel, 2000.

	Hours	Tagged				Not Tagged				Total			
Date	Fished	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative
8/16													
8/17													
8/18													
8/19	17	0	0	0	0	0	0	0	0	0	0	0	0
8/20	24	0	0	0	0	0	0	0	0	0	0	0	0
8/21	24	0	0	0	0	0	0	0	0	0	0	0	0
8/22	24	0	0	0	0	0	0	0	0	0	0	0	0
8/23	24	0	0	0	0	1	0	1	1	1	0	1	1
8/24	24	0	0	0	0	0	0	0	1	0	0	0	1
8/25	24	0	0	0	0	1	0	1	2	1	0	1	2
8/26	24	0	0	0	0	1	0	1	3	1	0	1	3
8/27	24	0	0	0	0	3	4	7	10	3	4	7	10
8/28	24	0	2	2	2	6	8	14	24	6	10	16	26
8/29	24	0	0	0	2	1	1	2	26	1	1	2	28
8/30	24	0	0	0	2	5	0	5	31	5	0	5	33
8/31	24	0	0	0	2	2	1	3	34	2	1	3	36
9/1	24	0	0	0	2	2	4	6	40	2	4	6	42
9/2	23	0	0	0	2	2	3	5	45	2	3	5	47
9/3	24	0	0	0	2	1	3	4	49	1	3	4	51
9/4	24	0	0	0	2	4	1	5	54	4	1	5	56
9/5	24	0	0	0	2	2	1	3	57	2	1	3	59
9/6	24	0	0	0	2	6	4	10	67	6	4	10	69
9/7	24	1	0	1	3	3	3	6	73	4	3	7	76
9/8	24	0	0	0	3	3	1	4	77	3	1	4	80
9/9	24	0	1	1	4	4	5	9	86	4	6	10	90
9/10	24	1	0	1	5	8	4	12	98	9	4	13	103
9/11	24	0	0	0	5	5	1	6	104	5	1	6	109
9/12	24	0	0	0	5	4	7	11	115	4	7	11	120
9/13	24	0	0	0	5	4	7	11	126	4	7	11	131
9/14	24	0	0	0	5	9	10	19	145	9	10	19	150
9/15	24	0	0	0	5	6	10	16	161	6	10	16	166
9/16	24	1	0	1	6	4	7	11	172	5	7	12	178
9/17	24	2	0	2	8	8	6	14	186	10	6	16	194
9/18	24	0	0	0	8	9	4	13	199	9	4	13	207
9/19	24	0	0	0	8	8	5	13	212	8	5	13	220
9/20	24	1	0	1	9	12	18	30	242	13	18	31	251
9/21	24	1	1	2	11	14	23	37	279	15	24	39	290
9/22	24	0	0	0	11	12	22	34	313	12	22	34	324
9/23	24	0	0	0	11	9	10	19	332	9	10	19	343
9/24	24	0	2	2	13	6	13	19	351	6	15	21	364
9/25	24	0	4	4	17	6	12	18	369	6	16	22	386
9/26	24	0	0	0	17	6	8	14	383	6	8	14	400
9/27	24	0	0	0	17	5	4	9	392	5	4	9	409
9/28	4	0	0	0	17	2	0	2	394	2	0	2	411
Total		7	10	17		184	210	394		191	220	411	

Appendix E. Daily effort and catch of tagged and untagged fall chum salmon in the Toklat River left bank recovery fish wheel, 2000.

	Hours	Tagged				Not Tagged				Total			
Date	Fished	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative
8/16													
8/17													
8/18	12	0	0	0	0	0	0	0	0	0	0	0	0
8/19	24	0	0	0	0	0	0	0	0	0	0	0	0
8/20	24	0	0	0	0	0	0	0	0	0	0	0	0
8/21	24	0	0	0	0	1	1	2	2	1	1	2	2
8/22	24	0	0	0	0	0	0	0	2	0	0	0	2
8/23	24	0	0	0	0	0	0	0	2	0	0	0	2
8/24	24	0	0	0	0	0	2	2	4	0	2	2	4
8/25	24	0	1	1	1	0	0	0	4	0	1	1	5
8/26	24	0	0	0	1	0	1	1	5	0	1	1	6
8/27	24	0	0	0	1	1	3	4	9	1	3	4	10
8/28	24	0	1	1	2	4	4	8	17	4	5	9	19
8/29	24	0	0	0	2	6	5	11	28	6	5	11	30
8/30	24	0	0	0	2	3	2	5	33	3	2	5	35
8/31	24	0	0	0	2	1	1	2	35	1	1	2	37
9/1	24	0	0	0	2	2	2	4	39	2	2	4	41
9/2	24	0	0	0	2	0	2	2	41	0	2	2	43
9/3	24	0	0	0	2	1	0	1	42	1	0	1	44
9/4	24	0	0	0	2	0	0	0	42	0	0	0	44
9/5	24	0	0	0	2	1	2	3	45	1	2	3	47
9/6	24	0	0	0	2	3	4	7	52	3	4	7	54
9/7	24	0	0	0	2	1	2	3	55	1	2	3	57
9/8	24	0	0	0	2	0	2	2	57	0	2	2	59
9/9	24	0	0	0	2	3	4	7	64	3	4	7	66
9/10	24	2	0	2	4	3	2	5	69	5	2	7	73
9/11	24	0	0	0	4	6	4	10	79	6	4	10	83
9/12	24	0	0	0	4	7	8	15	94	7	8	15	98
9/13	24	0	0	0	4	6	9	15	109	6	9	15	113
9/14	24	1	0	1	5	8	9	17	126	9	9	18	131
9/15	24	3	0	3	8	20	17	37	163	23	17	40	171
9/16	24	1	0	1	9	19	14	33	196	20	14	34	205
9/17	24	0	1	1	10	14	10	24	220	14	11	25	230
9/18	24	1	1	2	12	11	19	30	250	12	20	32	262
9/19	24	1	1	2	14	25	30	55	305	26	31	57	319
9/20	24	1	0	1	15	12	13	25	330	13	13	26	345
9/21	24	0	0	0	15	3	7	10	340	3	7	10	355
9/22	24	0	1	1	16	6	7	13	353	6	8	14	369
9/23	24	1	0	1	17	4	2	6	359	5	2	7	376
9/24	24	0	0	0	17	7	8	15	374	7	8	15	391
9/25	24	1	0	1	18	6	8	14	388	6	8	14	405
9/26	24	0	0	0	18	2	3	5	393	2	3	5	410
9/27	24	0	0	0	18	0	1	1	394	0	1	1	411
9/28	7	0	0	0	18	0	0	0	394	0	0	0	411
Total		12	6	18		186	208	394		197	214	411	

Appendix F. Daily effort and catch of tagged and untagged fall chum salmon in the Kantishna River recovery fish wheel, 2000.

	Hours	Tagged				Not Tagged				Total			
Date	Fished	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative	Males	Females	Total	Cumulative
8/16	24	0	0	0	0	1	1	2	2	1	1	2	2
8/17	24	0	0	0	0	1	1	2	4	1	1	2	4
8/18	20	0	0	0	0	1	2	3	7	1	2	3	7
8/19	24	0	0	0	0	0	1	1	8	0	1	1	8
8/20	24	0	0	0	0	2	0	2	10	2	0	2	10
8/21	24	0	0	0	0	1	1	2	12	1	1	2	12
8/22	24	0	0	0	0	1	0	1	13	1	0	1	13
8/23	24	0	0	0	0	2	2	4	17	2	2	4	17
8/24	24	0	0	0	0	0	0	0	17	0	0	0	17
8/25	24	0	0	0	0	2	1	3	20	2	1	3	20
8/26	24	0	0	0	0	0	0	0	20	0	0	0	20
8/27	24	0	0	0	0	3	4	7	27	3	4	7	27
8/28	24	0	1	1	1	2	5	7	34	2	6	8	35
8/29	24	1	0	1	2	6	3	9	43	7	3	10	45
8/30	24	1	1	2	4	1	2	3	46	2	3	5	50
8/31	24	0	0	0	4	2	1	3	49	2	1	3	53
9/1	24	0	0	0	4	2	1	3	52	2	1	3	56
9/2	24	0	0	0	4	2	1	3	55	2	1	3	59
9/3	24	1	0	1	5	0	2	2	57	1	2	3	62
9/4	24	0	0	0	5	2	7	9	66	2	7	9	71
9/5	24	0	0	0	5	1	0	1	67	1	0	1	72
9/6	24	0	0	0	5	3	3	6	73	3	3	6	78
9/7	24	0	0	0	5	0	0	0	73	0	0	0	78
9/8	24	0	0	0	5	3	6	9	82	3	6	9	87
9/9	24	0	0	0	5	4	3	7	89	4	3	7	94
9/10	24	1	0	1	6	2	3	5	94	3	3	6	100
9/11	24	0	0	0	6	6	5	11	105	6	5	11	111
9/12	24	0	0	0	6	8	3	11	116	8	3	11	122
9/13	19	0	0	0	6	2	7	9	125	2	7	9	131
9/14	24	0	0	0	6	7	6	13	138	7	6	13	144
9/15	24	0	0	0	6	5	11	16	154	5	11	16	160
9/16	14	0	0	0	6	4	4	8	162	4	4	8	168
9/17	23	0	0	0	6	6	5	11	173	6	5	11	179
9/18	24	0	2	2	8	8	7	15	188	8	9	17	196
9/19	25	1	0	1	9	2	12	14	202	3	12	15	211
9/20	23	0	1	1	10	5	5	10	212	5	6	11	222
9/21	24	0	0	0	10	10	14	24	236	10	14	24	246
9/22	24	0	0	0	10	7	12	19	255	7	12	19	265
9/23	12	0	0	0	10	3	5	8	263	3	5	8	273
9/24	24	0	0	0	10	2	1	3	266	2	1	3	276
9/25	24	0	0	0	10	4	1	5	271	4	1	5	281
9/26	24	0	0	0	10	2	3	5	276	2	3	5	286
9/27	24	1	0	1	11	2	2	4	280	3	2	5	291
9/28	24	0	0	0	11	1	3	4	284	1	3	4	295
9/29	24	0	0	0	11	4	0	4	288	4	0	4	299
9/30	24	0	0	0	11	0	1	1	289	0	1	1	300
10/1	24	0	0	0	11	0	5	5	294	0	5	5	305
10/2	24	0	0	0	11	0	0	0	294	0	0	0	305
Total		6	5	11		132	162	294		138	167	305	